

# PATENT SPECIFICATION

1,089,247

DRAWINGS ATTACHED.

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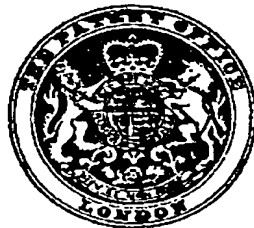
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1,089,247

## COMPLETE SPECIFICATION.

### Method of Manufacturing a Hollow Aerofoil Section Blade for a Fluid Flow Machine.

We, **ROLLS-ROYCE LIMITED**, a British Company of Nightingale Road, Derby, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a method of manufacturing a hollow aerofoil section blade for a fluid flow machine.

According to the present invention a method of manufacturing a hollow aerofoil section blade for a fluid flow machine comprises the steps of cutting out a pair of plates of metal in a shape required to form the concave and convex flank sections of the blade respectively, forming the plates to the required section, curvature and twist, welding the shaped flank sections together at their leading and trailing edges and welding shaped leading and trailing edge sections to the joined flank sections.

The said plates may be hot pressed to give them the necessary camber and twist and subsequently chemically machined to produce the required section and taper.

The leading and trailing edges of the joined flank sections may be machined to a desired shape before welding on the shaped leading and trailing edge sections.

The invention will now be particularly described merely by way of example with reference to the accompanying drawings in which:—

Figure 1 is an elevation of a gas turbine engine partly broken away to show blades made according to the present invention:—

Figure 2 is a perspective and partly exploded view of a blade made according to the present invention;

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Figure 3 is a section through the root of the blade shown in Figure 2;

Figure 4 is a section similar to Figure 3 of an alternative construction of the root section of the blade and,

Figure 5 is a transverse section through the blade of Figure 2.

Figure 1 shows a gas turbine engine 10 having a front fan 11, a compressor 12, combustion section 13, turbine section 14 and final nozzle 15 all in flow series. The casing of part of the fan 11 and compressor section 12 is broken away to show fan rotor blades 16.

Figure 2 is a perspective view of one of the blades 16. It will be understood that although the embodiment described is a fan rotor blade the invention is applicable to other types of blades. In order to clarify the construction of the blade 16 it is shown partly exploded in Figure 2 so that separate parts may be identified.

The blade 16 comprises a pair of flank sections 17 and 18. These flank sections are formed from plates of titanium. The plates are first cut to size. The plates are then clamped in a suitable jig and the root sections of the plates are upset to form a local thickening. The plates with the root thickening thus formed are then subjected to hot pressing which gives them their required camber and twist.

The shaped blanks formed by the hot pressing process are next chemically machined so as to form the required final shape. This machining process is used to taper the blanks to the required thickness and may leave stiffening ribs which are indicated at 19 in Figure 2 and may also leave features into which spacers may be

welded, such as the circular raised features indicated at 20 in Figure 2.

The pairs of shaped flanks thus formed are argon-arc welded down their leading and trailing edges so as to form the basis for a blade. The leading and trailing edges are next machined to provide a predetermined shape of edge and pre-shaped solid leading and trailing edge strips 21 and 22 are electron beam welded to these shaped edges.

The centres of the features 20 are then drilled out and tubular spacers 23 inserted and welded to the flank sections of the blade. In order to balance the blades and to arrange for their centres of gravity to be in a predetermined position the tubular spacers 23 may be filled with plugs 24 of materials of different densities. Thus resin material may be used or a metal plug may be inserted.

The construction of the finished blade can be seen from Figures 3 and 5. Figure 3 shows how the two thickened portions 25 and 26 at the root edge of the shaped flanks 17 and 18 coact to form a root section for the blade, and the features 20 together with the spacer 23 and plug 24 can be seen in section.

Figure 5 shows in section the flank portions 17 and 18 welded together with the leading and trailing edge portions 21 and 22 welded on. The features 20 can also be seen inside the hollow blade.

As an alternative to the method of manufacturing the root section described above it would be possible to pre-form a root section 25 as shown in Figure 4 and to weld this to the root edge of the flank sections 17 and 18. In this case the chemical machining step would be such as to leave a raised edge or land across the root edge of the flank sections.

It will be noted from Figure 5 that the dovetail section root is curved to a radius to follow the root camber of the aerofoil. This gives much improved distribution of stress and surface pressure when compared with a conventional straight root, because all sections of the root are symmetrical with the aerofoil supported by the dovetail.

This feature is also valuable in that by altering the axial position of the blade in its root the stagger angle of the blade may be altered to a certain extent. This may be useful particularly in development testing.

As described above the leading and trailing edge portions 21 and 22 are solid members so as to provide maximum resistance to the impact of objects such as birds. It would however be possible to construct these portions as tubular members or members having divergent strips which may be subsequently deformed so as to converge and produce the desired section.

#### WHAT WE CLAIM IS:—

1. A method of manufacturing a hollow aerofoil section blade for a fluid flow machine comprising the steps of cutting out a pair of plates of metal in a shape required to form the concave and convex flank sections of the blade respectively, forming the plates to the required section, curvature and twist, welding the shaped flank sections together at their leading and trailing edges and welding shaped leading and trailing edge sections to the joined flank sections.

2. A method of manufacturing a hollow aerofoil section blade for a fluid flow machine as claimed in claim 1 and in which said plates are hot pressed to give them the necessary camber and twist and subsequently chemically machined to produce the required section and taper.

3. A method of manufacturing a hollow aerofoil section blade for a fluid flow machine as claimed in claim 1 or claim 2 and in which the leading and trailing edges of the joined flank sections are machined to a desired shape before welding on the shaped leading and trailing edge sections.

4. A method of manufacturing a hollow aerofoil section blade for a fluid flow machine as claimed in claim 2 and in which the root portions of said plates are upset before said hot pressing step so as to form a local thickening, said root portions coacting to form the root of the blade when the sections are welded together.

5. A method of manufacturing a hollow aerofoil section blade for a fluid flow machine as claimed in any of claims 1—3 inclusive and in which the root of the blade is formed as a separate piece and welded to the joined flank sections.

6. A method of manufacturing a hollow aerofoil section blade for a fluid flow machine as claimed in any preceding claim and in which stiffening ribs are formed on the inner surfaces of both flank sections.

7. A method of manufacturing a hollow aerofoil section blade for a fluid flow machine as claimed in any preceding claim and in which there are spacer members extending between the flank sections.

8. A method of manufacturing a hollow aerofoil section blade for a fluid flow machine as claimed in claim 7 and in which the said spacers comprise tubes extending between the flank sections and in which the tubes are filled with material of a chosen density to enable the blade to be balanced.

9. A method of manufacturing a hollow aerofoil section blade for a fluid flow machine as claimed in any preceding claim and in which said root portions are curved to follow the root camber of the aerofoil.

10. A method of manufacturing a hollow aerofoil section blade for a fluid flow machine substantially as hereinbefore par-

ticularly described with reference to the accompanying drawings.

11. A hollow aerofoil section blade  
5 manufactured by the method of any of the preceding claims.

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COMPLETE SPECIFICATION

1 SHEET

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